The agri-food and other bio-based sectors in Spain.

A description based on multiplier analysis

M. A. Cardenete[1,2], P. Boulanger[1], M.C. Delgado[1,2], E. Ferrari[1], R. M'barek[1]

[1] European Commission, Joint Research Centre (JRC),
Institute for Prospective Technological Studies (IPTS), Seville, Spain.
[2] Universidad Pablo de Olavide (UPO), Seville, Spain.

emanuele.ferrari@ec.europa.eu

Paper prepared for presentation at the 1st AIEAA Conference
'Towards a Sustainable Bio-economy: Economic Issues and Policy Challenges'

4-5 June, 2012
Trento, Italy

Summary

The turnover of the EU agri-food sector overtops 2,000 billion Euros a year and employs roughly 22 millions workers. The focus of this paper is on the sectors directly linked to agricultural production and the food industry. Having a comprehensive understanding of extended agri-food economic linkages is critical when designing pertinent policies to deliver the full potential of strong EU agri-food and other bio-based sectors. A more disaggregated view is required. This study stars from a Social Accounting Matrices (SAM) for Spain with a highly disaggregated agricultural sector (AgroSAMs) for the year 2000. This study uses the AgroSAMs in its entire disaggregation, in order to provide a descriptive analysis of the agri-food and bio-based sectors. The limits of this approach are evident as many changes in the EU economies have taken place within a decade. However, the AgroSAMs are the only Pan-European database providing the details on all sectors mentioned. An update of the AgroSAMs for the year 2007 is ongoing and will provide more recent data and results .The focus is on Spain; nevertheless a review for every EU Member State is first performed to detect potential key sectors. The methodology adopted in this study allows the analysis of the EU agri-food and other bio-based sectors in space and time.

***Disclaimer**: The views expressed are purely those of the author and may not in any circumstances be regarded as stating an official position of the European Commission.*

Keywords: agriculture, food, multiplier, key sector, Spain

JEL Classification codes: C67, Q10, D57

The agri-food and other bio-based sectors in Spain. A description based on multiplier analysis

M. A. Cardenete[1,2], P. Boulanger[1], M.C. Delgado[1,2], E. Ferrari[1], R. M'barek[1]

[1] European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), Seville, Spain

[2] Universidad Pablo de Olavide (UPO), Seville, Spain.

1 INTRODUCTION

The EU agri-food and other bio-based sectors overtop 2,000 billion of Euros a year in turnover and employ roughly 22 millions workers (Table 1). The broad definition applied covers agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries. In 2009, compared to the agri-food sector, the bio-based industries represent a minor turnover – i.e. about 57 billion Euros.

Table 1 – Agri-food and other bio-based sectors in the European Union (EU)

Sector	Annual turnover	Employment	Data source
Food	965,000	4,400	CIAA
Agriculture	381,000	12,000	COPA-COGECA,
Paper/Pulp	375,000	1,800	CEPI
Forestry/Wood industry	269,000	3,000	CEI-BOIS
Fisheries and	32,000	500	EC***
Bio-based industries			
Bio-chemicals and plastics	50,000 (estimation*)	150 (estimation*)	USDA, Arthur D Little, Festel, McKinsey,
Enzymes	800 (estimation*)	5 (estimation*)	Amfep, Novozymes,
Biofuels	6,000 **	150	EBB, eBio
Total	2,078,000	22,005	

*Estimation for the EU for 2009

**Estimation based on a production of 2.2 million tonnes bioethanol and 7.7 million tonnes of biodiesel at average market price in the EU;

***EC, Facts and figures on the CFP, Basic Statistics Data, ISSN 1830-9119, 2010 Edition

Source: European Commission Staff Working Paper accompanying (COM(2012) 60 final).

Fostering the EU agri-food and other bio-based sectors is crucial for addressing major societal challenges:

- Ensuring food security and food safety
- Mitigating and adapting to climate change
- Managing in a sustainable way natural resources (water, soil, etc.)
- Providing new sources of energy while reducing dependency on fossil resources
- Creating jobs and fostering economic growth

Key for these challenges is a sustainable increase of agri-food productivity. This challenge requires an increase in targeted Research and Development (R&D) activities. However, funds allocated to R&D in agriculture are undersized, especially when comparing with those devoted to income support within the Common Agricultural Policy (CAP). In May 2011, the European Commission (EC) proposed to allocate during the 2014-2020 financial period 281.8 billions of Euros for the first pillar of the CAP (income support and direct payments) and 89.9 billions of Euros for the second pillar of the CAP (rural development measures). This funding shall be complemented by further 15.2 billion of Euros of which 4.5 billions for supporting research and innovation on food security, the bioeconomy and sustainable agriculture within the Common strategic framework for research and innovation (Horizon 2020). By contrast, for the period 2007-2013, programmes for research and technological development on food, agriculture and fisheries, and biotechnology were granted with 1.9 billion of Euros. This implies a significant increase in research and innovation funding for the next financial period.

In the Communication on the CAP after 2013, the EC proposed three objectives of the future CAP in which the agri-food and other bio-based sectors are directly targeted i.e. (i) viable food production, (ii) sustainable management of natural resources and climate action, and (iii) balanced territorial development. Within the first pillar of the CAP, greener and redistributed direct payments may contribute to foster an extended agri-food sector in the long-term. A range of rural development measures set together within the second pillar of the CAP may promote the agri-food and other bio-based sectors such as those focusing on competitiveness, innovation, pilot and demonstration projects, business development, knowledge transfer, advisory services, etc.

Considering social challenges, present economic slow down and budget constraints, public investments should target sectors that generate more income than the average sector in the economy. Thus, increasing productivity within key sectors should become a priority.

This study scrutinizes backward and forwards linkages as an indicator to identify agri-food and other bio-based key sectors based on a set of Social Accounting Matrices (SAM) with highly disaggregated agricultural and food industry sectors (AgroSAMs). Section 2 presents the methodology and the database. Section 3 provides a brief overview of potential agri-food and other bio-based related key sectors in Spain together with the analysis of the employment multipliers of these sectors. Section 4 concludes.

2. METHODOLOGY AND DATABASE

2.1 SAMs and IOTs: a brief introduction

Input-Output tables (IOTs) allow structural analyses of the composition of the economy and of production systems. Based on the input-output framework, Social Accounting Matrices (SAMs) represent all the economic transactions of an economy. SAMs contain information on economic agents such as producers, consumers, government and foreign sectors and on productive factors. A SAM attempts to integrate social statistics in the Input-Output Model productive sector's interdependence, representing in a matrix format an extension of these models.

Input-Output Tables collect the interdependence among productive sectors and their relations with final demand. In addition, the SAM includes all the transactions between productive factors and

components of final demand, thereby expanding the information provided by IOTs and completing the circular flow of income in a square matrix.

SAMs depict an economy at a certain point in time and can be used to describe the monetary flows of an economy. Secondly, SAMs are necessary databases for quantitative models (e.g. SAM linear models and Computable General Equilibrium models) able to assess the socioeconomic impact of different economic policies. Besides their statistical content, SAMs are useful tool to evaluate political interventions in national or regional frameworks.

In a SAM, each account is represented by a row and a corresponding column. By convention, rows show sources of income and columns how these revenues are allocated as expenditures. All the values in the cells are monetary flows. Therefore, each nonzero value of a cell reflects a transaction or a cash flow between accounts.

The SAM structure is flexible and can take different forms depending on the scope of the study. The number of accounts can vary and they may be more or less disaggregated. The disaggregation and the order of the different accounts depend on the model that will be built with the SAM and its implementation, with greater emphasis on those accounts that will be analyzed.

2.2 Key sector analysis

Two approaches have been commonly used in the literature for measuring the role played by a sector within an economy. The classical approach involves measuring multiplier effects based on estimated square multiplier matrices (Rasmussen, 1956, Chenery & Watanabe, 1958) with extensions identifying backward and forward linkages (Shultz, 1977, Cella, 1986, Clements, 1992, Heimler, 1991, Sonis et al, 1995, Sonis et al., 1997, Dietzenbacher, 2002). Multiplier effects can be seen as average ripple effects of a given economic structure. Once a multiplier matrix has been estimated, cells in columns and rows provide information on the bilateral linkage between each pair of sectors. By aggregating and averaging the entries in columns (or rows) sectors can be ranked according to the impact that an inflow in a given sector will transfer, on average, to the companion sectors through the mechanisms of mutual economic interdependencies. In the multiplier approach, all transmitted effects are quantified in terms of a hierarchy of positive contributions to output.

Key sector analysis allows extracting the main tendencies of an economy and developing its corresponding structural view. For this purpose, all sectors of an economy can be ranked according to a hierarchy derived on two types of indexes: a *backward linkage* (BL) and a *forward linkage* (FL), traditionally obtained from a symmetrical input-output table (SIOT).

The *backward linkage* (BL) indicator analyzes the effect on the economy of a change in the final demand of a sector. The *forward linkage* (FL) indicator evaluates the effect of a joint change in the final demand of all sectors on the production of a specific sector.

From these indicators, the key sectors of an economy can be individuated. Key sectors, due to their ability to generate high multiplier and fostering effect on production, allow designing economic policies and strategies of development based on the most relevant economic sectors.

Rasmussen (1956) proposed a methodology to individuate key sectors based on the inverse matrix associated $B_t = \left(I - A_t\right)^{-1}$, being I an identity matrix of size n, we obtain the expression of the BL:

$$B_{.j} = \sum_{i=1}^{n} b_{ij} \qquad j = 1...n \qquad \textbf{(1)}$$

b_{ij} denoting the elements of the inverse matrix associated B_t and sub- indexes i, j make reference respectively to the rows and columns of the corresponding matrix

Once this indicator is normalized, these coefficients can be easily interpreted. If the backward linkage is greater than one (BL_j greater than 100% in percentage terms), a unit change in the final demand of sector j will generate an increase above the average in the economy's global activity.

Jones (1976) stated that FL defined by Rasmussen (1956) is not a symmetrical measure if related to BL and, from a similar perspective, Augustinovics (1970) obtained FL as the row sum of the Goshian inverse, where the distribution coefficients (δ_{ij}) – obtained from the SIOT through dividing each cell by the row total, not the column total – replace the technical coefficients. This way, FL is calculated as O_i.:

$$O_{i.} = \sum_{j=1}^{n} \delta_{ij} \qquad i = 1...n \qquad \textbf{2}$$

From equation 2, the joint effect of altering the supply of primary inputs in a sector on all other sectors can be evaluated. After the normalization, if the forward linkage is above one (FL_i greater than 100% in percentages terms), a unit change in all sectors, will generate an increase above the average in sector i.

By definition, a key sector has both indexes greater than one. In this study, we adopt the concept of potential key sectors that can be defined as sectors with a BL greater than 0.9, independently of the FL. Thus, developing the FL of these agri-food and other bio-based sectors would convert them in true key sectors.

In addition to BL and FL analysis, an additional multiplier identifies the accounts that generate more employment when they receive a unitary exogenous injection. The employment multipliers are the result of a new diagonal matrix called E. This matrix includes the quotients between the volume of employment and the resources for each productive sector. This matrix is multiplied by the part of Ma that incorporates the rows and columns corresponding to the productive sectors. When increasing the income of an endogenous account, we obtain the impacts of this change in the column of the partition of Ma and, through the diagonal matrix E, we convert this impact into number of jobs. The expression of the employment multiplier, Me, is the following:

$$Me = E * Ma \qquad \textbf{3}$$

An element me_{ij}, is the increment in the number of employment of the sector i when the sector j receives a unitary exogenous injection[1]. Analyzing the sum of columns, we individuate the global effect on employment due to an exogenous increase by a monetary unit of demand in this sector. The

[1] Additional information about the employment multiplier and a comparison with other type of multipliers is provided in Arango (1979).

rows of the matrix show the increment that the sector experiences in its employment if the rest of sectors receive the exogenous monetary unit.

2.3 A tool to analyse SAMs and IOTs: SIMSIPSAM

SIMSIPASAM (Parra and Wodon, 2009) software benefitted from support of the World Bank and has been employed to perform the analyses of this report. SIMSIPSAM is an Excel based application to analyze SAMs and I-O tables. The tool makes use of MATLAB as computation engine. The application performs a large number of decompositions and analyses including two algorithms for SAM balancing (RAS and cross-entropy), SAM aggregation, multiplier decompositions, several types of economic linkages, income redistribution analysis, structural path analysis, several methods to analyze structural change (fields of influence, direction of change, importance of technical coefficients), supply constraints, price models, price controls, and poverty and income distribution analysis by linking the tool to household survey data.

2.4 The AgroSAM database

A comprehensive study of the agri-food and other bio-based requires a dataset able to disaggregate all the main economic sectors involved in the agri-food. The Joint Research Centre (JRC) of the EC has developed a set of Social Accounting Matrices (SAM) for the EU-27 with a highly disaggregated agricultural and agri-food sector (AgroSAMs) (Müller et al., 2009) for the year 2000. This dataset contributed the new I-O tables for all 27 EU member countries to the GTAP database since version 7.1.

National Supply- and Use-Tables (SUT) or symmetric Input-Output tables (IOT) are typically highly aggregated by agricultural sectors and commodities and thus provide little detail for sub-sector specific analysis. The agricultural sector is often represented as a single account in the national datasets. This coarse representation is an important reason for the limited application of SAM for analysis of agricultural related policies.

The AgroSAMs were constructed based on SUT provided by EuroStat. The agricultural sector has been comprehensively covered by integrating the database from the partial equilibrium (PE) agro-economic simulation model "Common Agricultural Policy Regionalized Impacts analysis modelling system" (CAPRI) (Britz and Witzke, 2008). These two main datasets have been processed to compile a specific dataset for each Member State covering agricultural and non-agricultural activities and commodities. This database was thought to allow modellers to better assess the issue of agricultural policies within each EU member state, e.g. the analysis of the impacts of 2013 CAP reforms on agricultural and non-agricultural sectors, with tools typical of the I-O or SAM analysis. This dataset permits a much more detailed analysis than existing databases thought for agricultural CGE analysis. In order to give an example, in the GTAP database – which is by large the most used database for CGE global analysis – distinguishes 12 raw agricultural products and 8 processed food commodities. Currently, the AgroSAM database contains 28 raw agricultural sectors and 12 processed food sectors and an agricultural service per each member state (Table 2). All the AgroSAMs contain 98 activities and 97 commodities[2]. The non-agricultural sectors are disaggregated according to the NACE 1.1 classification.

[2] The activity SETA - set aside - does not produce any commodity.

Table 2– Modified Agricultural Classification (MAC) for AgroSAMS

Modified agricultural classification (MAC)			
Code	**Description**	**Code**	**Description**
OWHE	Production of other wheat	**COMI**	Production of raw milk from bovine cattle
DWHE	Production of durum wheat	**LCAT**	Production of bovine cattle, live
BARL	Production of barley	**PIGF**	Production of swine, live
MAIZ	Production of grain maize	**SGMI**	Production of raw milk from sheep and goats
OCER	Production of other cereals (Rye, meslin and oats)	**LSGE**	Production of sheep, goats, horses, asses, mules and hinnies, live
PARI	Production of paddy rice	**EGGS**	Production of eggs
RAPE	Production of rape seed	**PLTR**	Production of poultry, live
SUNF	Production of sunflower seed	**OANM**	Production of other animals, live, and their products
SOYA	Production of soya seed	**RICE**	Processing of rice, milled or husked
OOIL	Production of other oil plants (Olive and seeds for oil industry)	**SUGA**	Processing of sugar
STPR	Production of other starch and protein plants (Pulses)	**VOIL**	Production of vegetable oils and fats, crude and refined; oil-cake and other solid residues, of vegetable fats or oils
POTA	Production of potatoes	**DAIR**	Dairy
SUGB	Production of sugar beet	**BFVL**	Production of meat of bovine animals, fresh, chilled, or frozen
FIBR	Production of fibre plants	**PORK**	Production of meat of swine, fresh, chilled, or frozen
OTCR	Other crop production activities (Industrial crops and straw)	**SGMT**	Production of meat of sheep, goats, and equines, fresh, chilled, or frozen
GRPS	Production of grapes	**POUM**	Meat and edible offal of poultry, fresh, chilled, or frozen
FVEG	Production of fresh vegetables, fruit, and nuts	**ANFD**	Production of prepared animal feeds
LPLT	Production of live plants	**OFOD***	Production of other food
SETA	Set aside	**BEVR**	Production of beverages
FODD	Production of fodder crops	**AGSV**	Agricultural service activities

*Production of Other Food includes: prepared and preserved fish or vegetables, fruit juices and vegetable juices, prepared and preserved fruit and nuts, all cereal flours, groats, meal and pellets of wheat, cereal groats, meal and pellets not else classified, other cereal grain products (including corn flakes), other vegetable flours and meals, mixes and doughs for the preparation of bakers' wares, starches and starch products; sugars and sugar syrups not else classified, preparations used in animal feeding, bakery products, cocoa, chocolate and sugar confectionery, macaroni, noodles, couscous and similar farinaceous products, food products not else classified. Source: Müller et al., (2009)

The AgroSAMs have been built following three main steps. First, consolidated macroeconomic indicators for EU27 have been compiled. Second, different datasets from EuroStat have been combined into a set of SAMs with aggregated agricultural and food-industry sectors. Third, these sectors have been disaggregated based on the CAPRI database.

The comparison of the activity accounts built on top of the CAPRI database and the SUT databases revealed that, despite some relevant differences in coverage and definition, the CAPRI database can be considered as a reliable source of information. Particularly, produced and trade quantities of agricultural goods, activity levels, output and input coefficients and basic prices are the

most reliable values. Other sources, as PRODCOM[3], are utilized to complete the database when they are not exhaustive as in the case of the food industry sectors.

The CAPRI and the SUTs, expressed in a SAM structure, are merged. This step cannot be done directly, because SUTs data are expressed on a mixture of basic and purchaser's price while the CAPRI database is measured only at basic prices. The a-priori SAM has been populated following a compilation procedure that is fully documented in Müller et al. (2009).

At the end of each of these three stages the datasets had to fulfil all the balancing criteria needed by a typical SAM. The method to balance the datasets draws heavily on the concept of Cross Entropy estimation (Golan et al., 1994). The structural deviations of agricultural sector and economy-wide data created a need to specify in which cases comparatively large deviations from recorded agricultural data could be tolerated, and in which cases not. For this purpose, Cross Entropy procedures proved to be extremely useful. The final matrixes are balanced through a cross-entropy approach, combined with a multiplicative disturbance term. The balancing process is constrained by the SUT totals and the CAPRI totals.

The integration of the CAPRI database with SUT tables represented the most relevant challenge and achievement of the project. The integration of the CAPRI database into a complete and consolidated set of SAMs for the EU27 raised several challenges. The first challenge came from the details of the CAPRI database, its format and its division between agricultural and food processing activities. Firstly, CAPRI was too detailed for the scope of the AgroSAM project. CAPRI contains data on manure production and use, fertilizer consumption, set-aside, milk quotas which are extremely demanding to be transformed into a SAM framework. In addition, the CAPRI database does not follow the "activity to commodity" typical structure of SAMs. Finally, the CAPRI database does not take into account other activities apart from agricultural ones. This represents a difficulty to treat sectors such as wine, meat and milk considered as processed food by the European System of National Accounts and end-of-pipe agricultural products by the CAPRI database.

In order to avoid technical problem linked to the functioning of the software employed for this study, a new version of AgroSAMs is produced. The original Supply and Use format is transformed into symmetric Input-Output tables using a product by product input – output tables[4]. This change facilitates the interpretation of the results (no differentiation between activities and commodities and consequent reduction of number of accounts) without distorting them.

3 SECTORAL ANALYSIS FOR SPAIN

3.1 Description of the Spanish AgroSAM

In 2000, the value added of the Spanish agri-food and other bio-based sectors amounted to about 83 billion of Euros, 15% of the Spanish value added (calculation based on AgroSAM). The 2007 SUT confirmed that these sectors have grown between 2000 and 2007, reaching a valued added of almost 110 billions of Euros but decreasing as a share of the Spanish value added (11.6%) (Table 3).

[3] Eurostat Statistics by Product: http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/introduction

[4] Following Eurostat Manual of Supply, model B: Product by product input – output tables based on industry technology assumption. Each industry has its own specific way of production, irrespective of its product mix.

The aggregated agricultural and food sectors represent the two largest agri-food and other bio-based sectors in terms of value added. The 2007 SUT shows that both sectors declined, in percentage terms, compared to the 2000 situation. The food sector value added experienced a relative decrease between 2000 and 2007, from 2.85% to 2.06% of the Spanish value added. The disaggregation of these sectors is recorded in Table 4.

Table 3– Agri-food and other bio-based sector relevance in the Spanish Economy, 2000, 2007

Value added	2000 Millions of Euros	Percentage of Total	2007 Millions of Euros	Percentage of Total
Agricultural sectors	21,435	3.77%	23,867	2.53%
Fish and forestry	2,677	0.47%	3,334	0.35%
Food sectors	16,200	2.85%	19,488	2.06%
Wood and products of wood and cork	2,550	0.45%	3,235	0.34%
Pulp and paper sector	2,915	0.51%	3,519	0.37%
Chemical sector	9,340	1.64%	13,172	1.39%
Rubber and plastic products	4,527	0.80%	5,711	0.60%
Other non-metallic mineral products	7,724	1.36%	11,604	1.23%
Furniture	5,021	0.88%	5,799	0.61%
Energy	9,053	1.59%	16,994	1.80%
Collected and purified water	1,745	0.31%	2,793	0.30%
Agri-food and other bio-based sectors	**83,188**	**14.64%**	**109,516**	**11.59%**
Value added	**568,041**	**100%**	**944,824**	**100%**

Source: Own elaboration from Eurostat (European Union EU27 Tables 2007).

In terms of value added, the chemical and energy sectors are other important extended agri-food manufacture sectors. The energy sector is the only one that between 2000 and 2007 registered a growth in absolute and in relative terms. All the other sectors, during the same period, produced a similar, even if decreasing, share of the Spanish value added.

Table 4 – Disaggregated agri-food sectors and their relevance in the Spanish Economy, 2000

Value added	Million of Euros
Production of other food	8,387.73
Production of fresh vegetables, fruit, and nuts	6,097.95
Production of beverages	4,061.79
Production of livestock*	3,017.87
Production of other oil plants	1,719.79
Dairy Products	1,433.28
Products of forestry, logging and related services	1,399.58
Fish and other fishing products; services incidental of fishing	1,277.82
Production of barley	1,053.38
Production of raw milk from bovine cattle	1,045.88
Production of poultry	1,012.81

*Production of bovine cattle, swine, sheep, goats, horses, assses, mules and hinnies, slaughtered
Source: Own elaboration.

Within the disaggregated agri-food sectors, the production of other food, fresh vegetable, fruits, and beverages represent the most important sectors for Spain in terms of value added in 2000.

3.2 Key sectors and employment issue

A sector is defined as "key" when its backward and forward linkages are greater than 1. A key sector can generate more income than the average sector in the economy and responds more to shocks than the average sector. In Table 1Table 5, Table 8 and Table 9 this assumption is relaxed by considering linkages greater than 0.9.

The *backward linkage* (BL) of sector j quantifies the change in the economy, relative to the average change in the economy, caused by a unitary injection in the final demand of sector j. In other words, the BL represents a diffusion effect.

Table 5 records the agri-food and other bio-based sectors with a BL greater than 0.9. In total, 33 activities have a BL greater than 0.9 9out of these 25 have BL greater than 1), indicating that several agri-food and bio-based sectors have a diffusion effect greater than the average.

Rapeseed production is the sector with the highest backward linkages i.e. a change of 1 euro in the final demand of this sector generates an increase in the activity of the other sectors of almost 3 Euros. However, rapeseed production in Spain is low (only 31,000 ha) thus, this result is not highly relevant.

Table 5 – Positive extended agri-food backward linkages, Spain, 2000

	Code	**BL**	**Description**
7	C_RAPE	2.882	Rape seed*
21	C_LCAT	1.376	Bovine cattle, slaughtered
42	C_SGMT	1.328	Meat of sheep, goats, and equines, fresh, chilled, or frozen
23	C_SGMI	1.324	Raw milk from sheep and goats
41	C_PORK	1.318	Meat of swine, fresh, chilled, or frozen
22	C_PIGF	1.251	Swine, slaughtered
24	C_LSGE	1.251	Sheep, goats, horses, asses, mules and hinnies, slaughtered
43	C_POUM	1.233	Meat and edible offal of poultry, fresh, chilled, or frozen
19	C_FODD	1.221	Fodder crops
40	C_BFVL	1.216	Meat of bovine animals, fresh, chilled, or frozen
69	C_WATR	1.205	Collected and purified water, distribution services of water
26	C_PLTR	1.180	Poultry, slaughtered
27	C_OANM	1.175	Other animals, live, and their products
20	C_COMI	1.173	Raw milk from bovine cattle
3	C_BARL	1.148	Barley
39	C_DAIR	1.147	Dairy products
15	C_OTCR	1.141	Other crop products
25	C_EGGS	1.141	Eggs
10	C_OOIL	1.125	Other oil plants
14	C_FIBR	1.119	Fibre plants
18	C_LPLT	1.117	Live plants
13	C_SUGB	1.099	Sugar beet
45	C_ANFD	1.013	Prepared animal feeds
50	C_WOOD	1.010	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials
68	C_EGSW	1.003	Electrical energy, gas, steam and hot water
56	C_NMMP	0.998	Other non-metallic mineral products
35	C_RICE	0.972	Rice, milled or husked

5	C_OCER	0.970	Other cereals
44	C_BEVR	0.959	Beverages
29	C_FORE	0.937	Products of forestry, logging and related services
6	C_PARI	0.933	Paddy rice
38	C_VOIL	0.926	Vegetable oils and fats, crude and refined; oil-cake and other solid residues, of vegetable fats or oils
37	C_SUGA	0.918	Processed sugar

* Data not relevant: Rap seed covered 31,000 ha in Spain in 2000
Source: Own elaboration.

Livestock and related products (including fodder, milk and dairy products) are the sectors with the greatest capacity to diffuse income within the Spanish economy.

Table 6 and Table 7 provide some basic information on the livestock sector in 2000 and 2007. The livestock sector (e.g. pigs and cattle) grew in the last decade, in terms of animal heads (pigs grew by 17% between 2000 and 2007) and of value of production. The value of production increased for all livestock (cattle 35%, pig 20%, and poultry 49%) but sheep and goats which, mainly due to the decrease of subsidies since 2006 the value of production fell between 2007 and 2000. An interesting case is represented by the milk sector. In this sector the number of dairy cows fell by more than 20% while the production increased by 0.7% and the value of production by more than 27%. These data seems to indicate the capacity of milk farmers to raise their productivity in order to react to market incentives.

Table 6– Number of heads, Spain, thousands, 2000, 2007

	2000	**2007**	**2000-2007 % change**
Pigs	22,149.3	26,061.2	17.7%
Sheep	24,927.4	22,194.3	-11.0%
Goats	2,875.7	2,891.6	0.6%
Cattles	6,216.9	6,585.0	5.9%
Cows	3,048.2	2,973.8	-2.4%
Other cows	1,897.1	2,070.5	9.1%
Dairy cows	1,151.0	903.3	-21.5%
Cows' milk*	*6,289.7**	*6,335.3**	*0.7%**

* Cow's milk in thousands tonnes
Source: Eurostat

Table 7 – Production value at producer price*, Spain, million Euros, 2000, 2007

	2000	**2007**	**2000-2007 % change**
Cattle	1,813.7	2,462.5	35.8%
Pigs	3,794.3	4,571.5	20.5%
Equines	68.8	83.1	20.8%
Sheep and goats	1,356.1	1,302.0	-4.0%
Poultry	1,227.7	1,833.4	49.3%
Other animals	320.1	197.6	-38.3%
Milk	2,163.6	2,760.4	27.6%
Eggs	794.6	1,012.9	27.5%

* Subsidies on product are included
Source: Eurostat

The *forward linkage* (FL) of sector j quantifies the change in income for sector j, relative to the average change in the economy, caused by a unitary injection in the final demand of all sectors. In other words the FL represents an absorption effect.

Table 8 – Positive extended agri-food forward linkages, Spain, 2000

	Code	FL	Description
54	C_CHEM	2.182	Chemicals, chemical products and man-made fibres
36	C_OFOD	1.563	Other food products
68	C_EGSW	1.098	Electrical energy, gas, steam and hot water
44	C_BEVR	0.934	Beverages

Source: Own elaboration.

Table 8 lists the agri-food and other bio-based sectors with a forward linkage greater than 0.9. Contrary to the BL analysis, the number of agri-food and bio-based sector with absorption effect greater than the average is more limited as only five of them have a Bl greater than 0.9 and four greater then 1. None of these five is a primary agricultural sector, while two of them, food products and beverages, are food industry sectors.

The sector "other food products"[5] has a significant forward linkage or absorption effect i.e. a change of one unit in the final demand of all sectors produces an increase in other food product production of more than 56% above the average. It is "almost" a key sector (cf. below). Second, chemicals, chemical products and man-made fibres present a high absorption effect i.e. are impacted by the rest of the sectors of the economy to a larger extend than the average reaction.

Following the definition of the backward and forward linkages in Spain's year 2000 economy, only one agri-food and other bio-based sector, "electrical energy, gas, steam and hot water", fulfils the criteria to be defined "key sector" (Table 9).

Table 9 – Key agri-food and other bio-based sectors, Spain, 2000

	Code	BL	FL	Description
36	C_OFOD	**0,835**	1.563	Other food products
68	C_EGSW	1.003	1.098	Electrical energy, gas, steam and hot water
44	C_BEVR	**0.959**	**0.934**	Beverages

Source: Own elaboration.

The key sector analysis allows three main observations (Table 9). Firstly, no primary production sector is a key sector. Secondly, energy is a key sector representing important links to the agri-food sector and other bio-based sectors as it uses natural and renewable resources in the production process. The food and agriculture sector can contribute renewable energy to final energy markets in different ways (production of biofuels or biogas, production of dedicated (non-food) energy crops and of second-generation biofuels, biogas and the energies derived from primary solid biomass, agricultural wastes and residues, wind and solar energy used for electricity generation, organic waste produced in the agri-food chain) (OECD, 2011).

Thirdly, production of beverages and other food products are "almost" key sectors.

[5] This sector contains the following subsectors: processing and preserving of fish and fish products, processing and preserving of fruit and vegetables, manufacture of grain mill products, starches and starch products and manufacture of other food products.

Table 10 and Table 11 provide the full backward and forward linkage dataset for Spain.

The analysis of the Spanish agri-food and bio-based sectors for the year 2000 is visualised in Figures 1 and 2 and clearly shows that half of the sectors are classified as weak, whereas the other half has positive backward linkages. However, none but one of the sectors are key.

Table 10 – Extended agri-food backward linkages – full results, Spain, 2000

	Description	**Code**	**BL**
9	Soya seed	C_SOYA	0.260
28	Agricultural services	C_AGSV	0.306
46	Tobacco products	C_TOBA	0.415
30	Fish and other fishing products; services incidental of fishing	C_FISH	0.694
54	Chemicals, chemical products and man-made fibres	C_CHEM	0.696
17	Fresh vegetables, fruit, and nuts	C_FVEG	0.697
1	Other wheat	C_OWHE	0.747
11	Other starch and protein plants	C_STPR	0.750
4	Grain maize	C_MAIZ	0.753
51	Pulp, paper and paper products	C_PULP	0.823
36	Other food products	C_OFOD	0.835
8	Sunflower seed	C_SUNF	0.845
12	Potatoes	C_POTA	0.855
2	Durum wheat	C_DWHE	0.856
55	Rubber and plastic products	C_PLST	0.868
16	Grapes	C_GRPS	0.875
37	Processed sugar	C_SUGA	0.918
38	Vegetable oils and fats	C_VOIL	0.926
6	Paddy rice	C_PARI	0.933
29	Products of forestry, logging and related services	C_FORE	0.937
44	Beverages	C_BEVR	0.959
5	Other cereals	C_OCER	0.970
35	Rice, milled or husked	C_RICE	0.972
56	Other non-metallic mineral products	C_NMMP	0.998
68	Electrical energy, gas, steam and hot water	C_EGSW	1.003
50	Wood and products of wood and cork (except furniture); straw and plaiting materials	C_WOOD	1.010
45	Prepared animal feeds	C_ANFD	1.013
13	Sugar beet	C_SUGB	1.099
18	Live plants	C_LPLT	1.117
14	Fibre plants	C_FIBR	1.119
10	Other oil plants	C_OOIL	1.125
25	Eggs	C_EGGS	1.141
15	Other crop products	C_OTCR	1.141
39	Dairy products	C_DAIR	1.147
3	Barley	C_BARL	1.148
20	Raw milk from bovine cattle	C_COMI	1.173
27	Other animals, live, and their products	C_OANM	1.175
26	Poultry, slaughtered	C_PLTR	1.180
69	Collected and purified water, distribution services of water	C_WATR	1.205
40	Meat of bovine animals, fresh, chilled, or frozen	C_BFVL	1.216
19	Fodder crops	C_FODD	1.221

43	Meat and edible offal of poultry, fresh, chilled, or frozen	C_POUM	1.233
24	Sheep, goats, horses, asses, mules and hinnies, slaughtered	C_LSGE	1.251
22	Swine, slaughtered	C_PIGF	1.251
41	Meat of swine, fresh, chilled, or frozen	C_PORK	1.318
23	Raw milk from sheep and goats	C_SGMI	1.324
42	Meat of sheep, goats, and equines, fresh, chilled, or frozen	C_SGMT	1.328
21	Bovine cattle, slaughtered	C_LCAT	1.376
7	Rape seed	C_RAPE	2.882

Source: Own elaboration.

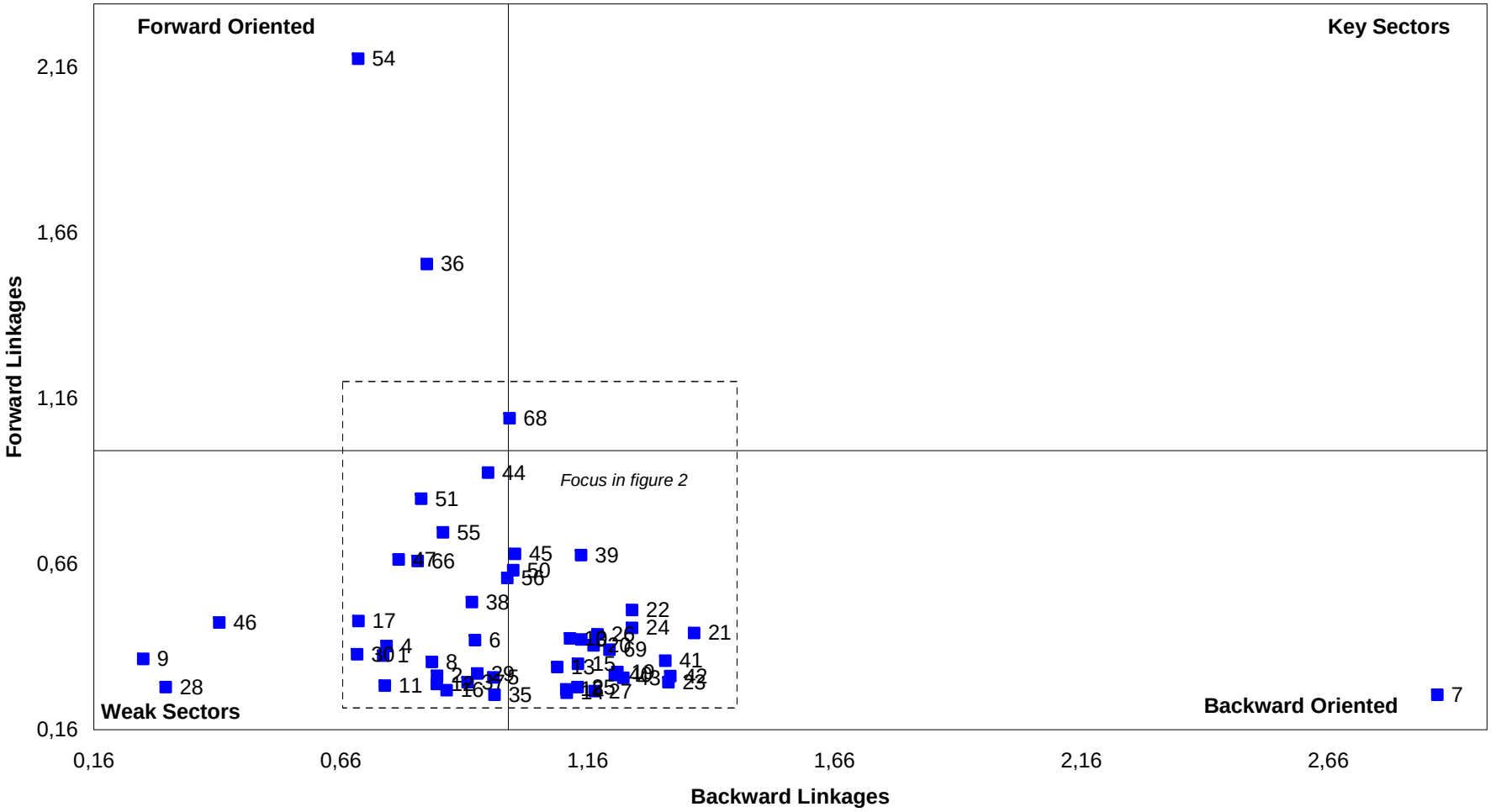
Table 11 **– Extended agri-food forward linkages – full results, Spain, 2000**

	Description	**Code**	**FL**
7	Rape seed	C_RAPE	0.263
35	Rice, milled or husked	C_RICE	0.263
14	Fibre plants	C_FIBR	0.269
27	Other animals, live, and their products	C_OANM	0.274
16	Grapes	C_GRPS	0.278
18	Live plants	C_LPLT	0.280
25	Eggs	C_EGGS	0.286
28	Agricultural services	C_AGSV	0.287
11	Other starch and protein plants	C_STPR	0.291
12	Potatoes	C_POTA	0.296
37	Processed sugar	C_SUGA	0.301
23	Raw milk from sheep and goats	C_SGMI	0.301
43	Meat and edible offal of poultry, fresh, chilled, or frozen	C_POUM	0.314
5	Other cereals	C_OCER	0.316
42	Meat of sheep, goats, and equines, fresh, chilled, or frozen	C_SGMT	0.320
2	Durum wheat	C_DWHE	0.320
40	Meat of bovine animals, fresh, chilled, or frozen	C_BFVL	0.323
29	Products of forestry, logging and related services	C_FORE	0.328
19	Fodder crops	C_FODD	0.332
13	Sugar beet	C_SUGB	0.346
15	Other crop products	C_OTCR	0.357
8	Sunflower seed	C_SUNF	0.363
41	Meat of swine, fresh, chilled, or frozen	C_PORK	0.366
9	Soya seed	C_SOYA	0.372
1	Other wheat	C_OWHE	0.382
30	Fish and other fishing products; services incidental of fishing	C_FISH	0.386
69	Collected and purified water, distribution services of water	C_WATR	0.400
4	Grain maize	C_MAIZ	0.410
20	Raw milk from bovine cattle	C_COMI	0.413
6	Paddy rice	C_PARI	0.428
3	Barley	C_BARL	0.431
10	Other oil plants	C_OOIL	0.433
26	Poultry, slaughtered	C_PLTR	0.445
21	Bovine cattle, slaughtered	C_LCAT	0.450
24	Sheep, goats, horses, asses, mules and hinnies, slaughtered	C_LSGE	0.465
46	Tobacco products	C_TOBA	0.481
17	Fresh vegetables, fruit, and nuts	C_FVEG	0.486
22	Swine, slaughtered	C_PIGF	0.519
38	Vegetable oils and fats	C_VOIL	0.543
56	Other non-metallic mineral products	C_NMMP	0.616
50	Wood and products of wood and cork (except furniture); straw and plaiting materials	C_WOOD	0.639
39	Dairy products	C_DAIR	0.685
45	Prepared animal feeds	C_ANFD	0.689
55	Rubber and plastic products	C_PLST	0.754
51	Pulp, paper and paper products	C_PULP	0.855
44	Beverages	C_BEVR	0.934

68	Electrical energy, gas, steam and hot water	C_EGSW	1.098
36	Other food products	C_OFOD	1.563
54	Chemicals, chemical products and man-made fibres	C_CHEM	2.182

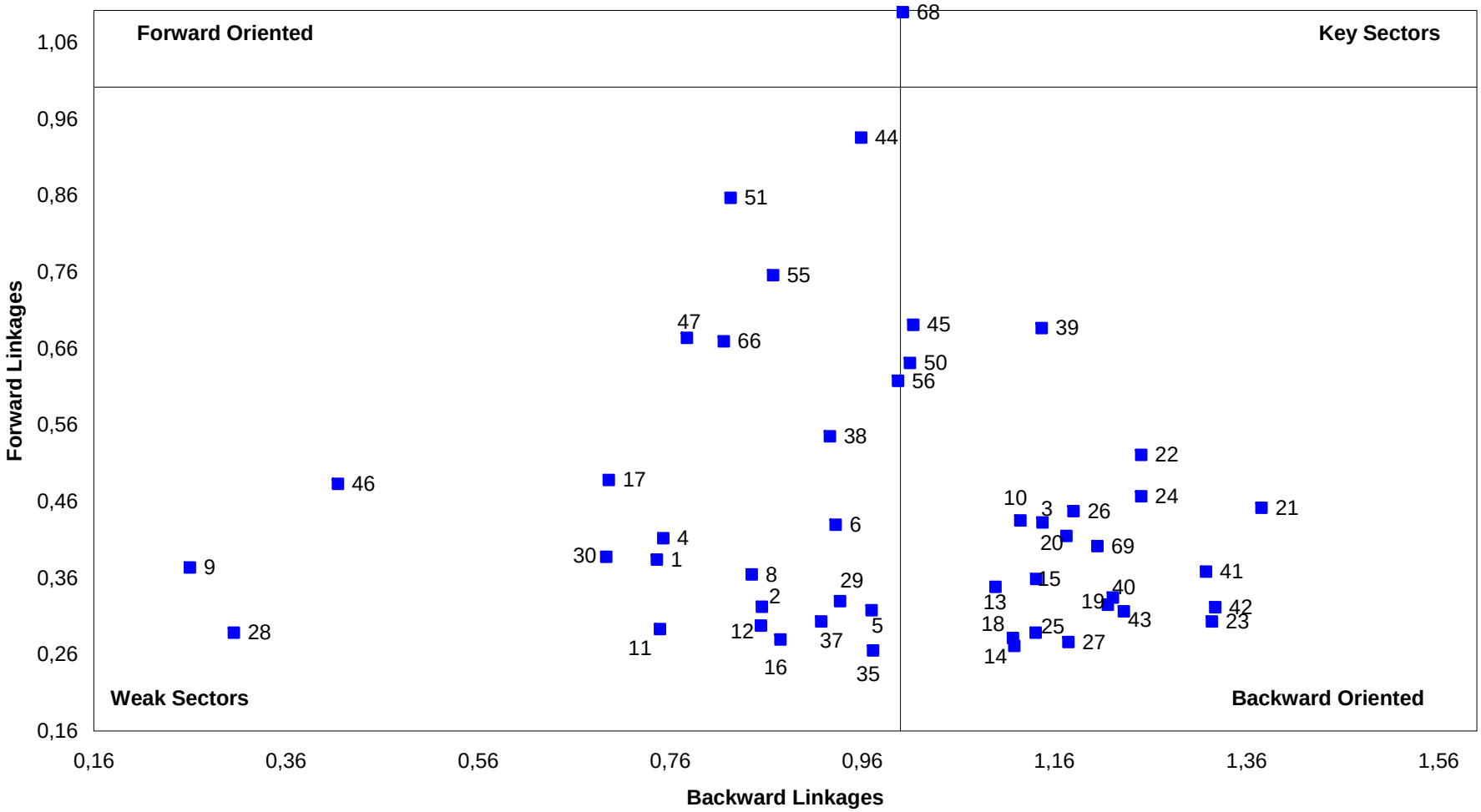
Source: Own elaboration.

Figure 1.
Structural overview of the agri-food and other bio-based sectors, Spain, 2000



Note: For data specification, see Table 10 and Table 11. Source: Own elaboration.

Figure 2.
Structural overview of the agri-food and other bio-based sectors (focus), Spain, 2000



Note: For data specification, see Table 10 and Table 11.Source: Own elaboration.

Table 12 – Extended agri-food employment multiplier, Spain, 2000.

	Code	Description	Employment multiplier
1	C_OWHE	Other wheat	6.57
2	C_DWHE	Durum wheat	5.35
3	C_BARL	Barley	8.07
4	C_MAIZ	Grain maize	7.44
5	C_OCER	Other cereals	7.68
6	C_PARI	Paddy rice	4.31
7	C_RAPE	Rape seed	4.88
8	C_SUNF	Sunflower seed	7.19
9	C_SOYA	Soya seed	4.97
10	C_OOIL	Other oil plants	5.07
11	C_STPR	Other starch and protein plants	14.67
12	C_POTA	Potatoes	6.87
13	C_SUGB	Sugar beet	10.28
14	C_FIBR	Fibre plants	7.91
16	C_GRPS	Grapes	3.34
17	C_FVEG	Fresh vegetables, fruit, and nuts	5.04
18	C_LPLT	Live plants	6.99
19	C_FODD	Fodder crops	8.65
20	C_COMI	Raw milk from bovine cattle	22.36
21	C_LCAT	Bovine cattle, slaughtered	0.83
22	C_PIGF	Swine, slaughtered	0.98
23	C_SGMI	Raw milk from sheep and goats	18.78
24	C_LSGE	Sheep, goats, horses, asses, mules and hinnies, slaughtered	0.96
25	C_EGGS	Eggs	0.41
26	C_PLTR	Poultry, slaughtered	1.00
28	C_AGSV	Agricultural services	14.84
29	C_FORE	Products of forestry, logging and related services	13.94
30	C_FISH	Fish and other fishing products; services incidental of fishing	10.45
35	C_RICE	Rice, milled or husked	26.31
36	C_OFOD	Other food products	5.30
37	C_SUGA	Processed sugar	15.93
38	C_VOIL	Vegetable oils and fats	1.28
39	C_DAIR	Dairy products	1.22
40	C_BFVL	Meat of bovine animals, fresh, chilled, or frozen	1.37
41	C_PORK	Meat of swine, fresh, chilled, or frozen	1.43
42	C_SGMT	Meat of sheep, goats, and equines, fresh, chilled, or frozen	2.33
43	C_POUM	Meat and edible offal of poultry, fresh, chilled, or frozen	2.33
44	C_BEVR	Beverages	0.57
45	C_ANFD	Prepared animal feeds	12.37
46	C_TOBA	Tobacco products	0.80
47	C_TEXT	Textiles	6.39
50	C_WOOD	Wood and products of wood and cork (except furniture); straw and plaiting materials	8.47
51	C_PULP	Pulp, paper and paper products	3.24
54	C_CHEM	Chemicals, chemical products and man-made fibres	2.27
55	C_PLST	Rubber and plastic products	5.48
56	C_NMMP	Other non-metallic mineral products	6.36
66	C_FURN	Furniture; other manufactured goods n.e.c.	8.87
68	C_EGSW	Electrical energy, gas, steam and hot water	1.64

69	C_WATR	Collected and purified water, distribution services of water	11.42
		TOTAL	**335.21**

Note: Employment multiplier of "(15) other crops products" and "(27) other animals, live, and their products" are excluded from the analysis for consistency reason (employment residual).
Source: Own elaboration

Finally, Table 12 presents the employment content of each agri-food and other bio-based sector in Spain i.e. the number of jobs, on a full time basis, generated by one million Euros increase of the respective output sector.

4. CONCLUDING REMARKS

This study stresses the capacity of a Social Accounting Matrix (SAM) with a highly disaggregated agricultural sector (AgroSAM) to provide descriptive analysis of the agri-food and other bio-based sectors in 2000.[6] The software SIMIPSAM is used to detect backward and forward structural linkages as well as key sectors with the aim to reveal likely growth, a key element in the design of public and private policies. It presents the Spanish employment multiplier, to show the most significant sectors in term of job creation.

The key sector analysis for Spain leads to three remarks. First, it highlights that no primary agricultural sectors result as key for the Spanish economy. The production of energy appears as the only key sector related to an extended agri-food sector, given a potential high and mix consumption of intermediate. Energy uses natural and renewable resources in the production process – such as conventional agricultural or energy crops, agricultural or agri-food chain wastes and residues, wind, solar, etc. – it should be critical in any attempt of fostering the bio-based economy in Spain.[7] These results for Spain are consistent with other studies using more aggregated SAMs in Cardenete (2008) and Cardenete et al (2008).

Second, the "other food products" sector has a forward linkage or an absorption effect greater than the average i.e. an increase in the final demand of all sectors produces a higher increase in other food product activities relative to the average change in the economy. In addition, the sector "chemicals, chemical products and man-made fibres" presents a high absorption effect i.e. is impacted by the rest of the sectors of the economy to a larger extend than the average reaction. As for the energy sector, the chemical sector is related to the agri-food and other bio-based sectors given the amount of natural and renewable resources used in its production process.

Finally, livestock and related products (including fodder, milk and dairy products) present the highest backward linkages within the extended agri-food sectors i.e. a change of 1 euro in the finale demand of these sectors generates an increase in the activity of the other sectors higher than 1 euro. This result is relevant for most of EU Member States in 2000.

This original key sector snapshot may contribute to better understand economic linkages of agri-food and bio-based sectors. Targeting public intervention to those sectors that generate more income than the average sector should be a priority to make the EU a smart, sustainable and inclusive economy.

[6] AgroSAMs are currently in updating process to the year 2007. Currently, the dataset is for the year 2000. Thus macroeconomic adjustments and policy changes occurred since 2000, notably 2003-2004-2008 CAP reforms, are not taken into account.

[7] One may highlight that electricity from natural and renewable resources increased by over 40% between 1999 and 2009 in Spain. It accounted by about 25% of Spain's gross electricity production in 2009 (Data from the Spain's national renewable energy action plan 2011-2020 released in June 2010 by the Spanish Ministry of industry, tourism and trade).

REFERENCES

Arango, J. (1979) ”Multiplicadores derivados de un modelo input-output regional”, Investigaciones Económicas, 8, pp. 5-26.

Augustinovics, M. (1970) “Methods of International and Intertemporal Comparison of Structure” in A.P. Carter and A. Bródy (Ed.) Contributions to Input-Output Analysis, pp. 249-269, Amsterdam, North-Holland.

Britz, W. and Witzke, H.P. (eds.) (2008) “CAPRI Model Documentation 2008: Version 2”, University of Bonn (http://www.capri-model.org/docs/capri_documentation.pdf).

Cardenete, M.A. (2008) “Factores que influyen en la creación y consolidación de empresas”, Fundación EOI Escuela de Negocios, Ministerio de Industria, Energía y Turismo.

Cardenete, M.A., Lima, C., Morilla, C. and Llanes, G.J. (2008) “Detection of Key Sectors by Using a Social Accounting Matrices: an Alternative Approach”, Journal of Applied Input-Output Analysis, 13-14, pp. 83-91.

Cella, G. (1984) “The Input-Output Measurement of Interindustry Linkages”, Oxford Bulletin of Economics and Statistics, 46, pp.73-84.

Chenery, H.B. and Watanabe, T. (1958) “International Comparisons of the Structure of Production”, Econometrica, 26, pp. 487-521.

Clements, J. B. (1990) “On the Decomposition and Normalization of Interindustry Linkages”, Economics Letters, 33, pp.337-340.

Dietzenbacher, E. (2002) “Interregional Multipliers: Looking Backward, Looking Forward”, Regional Studies, 36, pp.125-136.

Eurostat (2008) “Eurostat Manual of Supply, Use and Input – Output Tables”.

Heimler, A. (1991) “Linkages and Vertical Integration in the Chinese Economy”, Review of Economics and Statistics, 73, pp. 261-267.

Jones, L.P. (1976) “The Measurement of Hirschman Linkages”, Quarterly of Journal of Economics, 90, pp. 323-333.

Müller, M., Perez-Dominguez, I. and Gay, S.H. (2009) “Construction of Social accounting Matrices for EU27 with a Disaggregated Agricultural Sectors (AgroSAM)”, JRC Scientific and Technical Reports http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=2679.

OECD (2011) “Food and Agriculture” OECD Green Growth Studies, Paris.

Parra, J. C. and Wodon, G. (2009) “SimSIP SAM: A Tool to Analyze Social Accounting Matrices”, mimeo, The World Bank, Washington, DC.

Rasmussen, P. (1956) “Studies in Inter-Sectorial relations”, Einar Harks, Copenhagen.

Sonis, M., Guilhoto, J., Hewings, G. and Martins, E.B. (1995) “Linkages, Key Sectors, and Structural Change: Some New Perspectives”, Developing Economies, 33, pp. 233-270.

Sonis, M., Hewings, G. and Miyazawa, K. (1997) “Synergetic Interactions Within the Pairwise Hierarchy of Economic Linkages Subsystems”, Hitotsubashi Journal of Economics, 38(2), pp.183-199.